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AUTHOR Heath, Robert W.; And Others
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ABSTRACT

Ninety-three indigenous Hawaiian or part-Hawaiian preschoolers were screened for hearing dysfunction; approximately 85 percent of the children failed the screening, which included pure-tone audiometry, tympanometry, and otoscopy. The research literature indicates that from 30 to 35% of all children experience recurring episodes of "silent" otitis media during the preschool years, with enduring hearing effects for weeks or months following each episode. The screening results noted in the present study were felt to be valid because the findings were congruent among the three screening techniques, and the children who failed the screening tended to have lower scores on tests of language skills (the Peabody Picture Vocabulary Test and five tests from the circus battery). The poor performance was still apparent when the children were retested 8 months after the screening. Though Hawaiian children were more likely to fail the hearing screening than non-Hawaiian children, generally no relationships between family characteristics (such as sibling-set size or income) and hearing dysfunction were found. Certain ethnic groups may be at greater risk than the general population. As a medical solution to this problem is not forthcoming, educators must take the responsibility to develop techniques that are useful in counteracting the consequences of hearing dysfunction (primarily diminished language competence), even though the effectiveness of such techniques has not been proved. (JDD)

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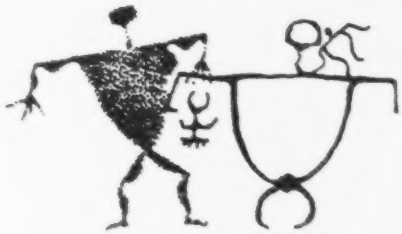

HEARING DYSFUNCTION IN HAWAIIAN PRESCHOOLERS: ITS RELATION TO EDUCATIONAL ACHIEVEMENT AND FAMILY CHARACTERISTICS

Robert W. Heath, Jerald D. Plett,

Katherine A. Tibbetts, & Pamela H. Medeiros

Center for Development of Early Education

Evaluation Department

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Kamehameha Schools/Bernice Pauahi Bishop Estate

1850 Makuakane Street, Honolulu, Hawai'i 96817

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ABSTRACT

At the beginning of the 1985-1986 school year 93 Hawaiian/part-Hawaiian children entering Kamehameha Schools' preschools were screened for hearing dysfunction. Screening was conducted by audiologists from a children's hospital. These preschoolers were also administered a battery of achievement tests at the beginning and the close of the school year. The relationship of hearing dysfunction to the various measures of academic achievement and to a number of family characteristics is analyzed. Approximately 85% of the children did not pass the hearing screening. The relationship between hearing dysfunction and achievement test performance was statistically significant for a number of tests, for both pre- and post-testing. The results of these analyses are discussed in the context of the recent literature on otitis media, ethnicity, and academic performance. Implications for planning educational programs for young children are considered.

HEARING DYSFUNCTION IN HAWAIIAN PRESCHOOLERS: ITS RELATION TO EDUCATIONAL ACHIEVEMENT AND FAMILY CHARACTERISTICS

I. INTRODUCTION

At the beginning of the 1985-86 school year 93 Hawaiian/part-Hawaiian preschoolers entered Kamehameha Schools and were screened for hearing dysfunction by the Kapiolani Women's and Children's Medical Center. Screening included pure-tone audiometry, tympanometry, and otoscopy. Approximately 85% of these children did not pass the screening.

This report presents the results of investigations that sought answers to these questions:

How unusual are such findings?

Is it likely that these findings are in error?

Is this incidence of hearing dysfunction unique to ethnic-Hawaiian children?

Are such findings a function of the screening methods used?

Is hearing dysfunction among Hawaiian children related to family characteristics such as socio-economic status, family size, and parental marital status?

Is this kind of hearing dysfunction related to children's performance on educational tests?

What is the relation of hearing dysfunction at the time of entering preschool to later assessments of educational performance?

What are the implications of these findings for educational program planning for Hawaiian preschoolers?

We have not found definitive answers to all these questions. However, we have reasonably good responses to some and hope to find support for the research needed to answer the others.

The hearing-screening program for Kamehameha Schools preschool children was initiated to identify those children who had hearing problems so that their parents could be referred to appropriate medical-care specialists. It was expected that only a small percentage of the children would fail the hearing-screening. It immediately became evident that the familiar model of screening for a few extreme cases that required medical referral did not fit our reality.

Our data indicate that, in addition to the cases of active middle-ear disease (20%), a large majority of preschoolers experience intermittent hearing loss with long-term educational consequences. The development of language competence is particularly vulnerable to these recurring episodes of hearing dysfunction. The dominant cause of this hearing dysfunction is otitis media with effusion (middle-ear disease with fluid that often remains behind the tympanic membrane for months after the acute infection has subsided).

Reviews of the research literature by Feagans (in press) and Stewart (1985) as well as our own search indicate that: (a) the high incidence of

hearing dysfunction reported here is not unique, (b) family characteristics, typical of the population we serve, are associated with a higher incidence of otitis media, and (c) significant relationships exist between otitis media, hearing dysfunction, and later language learning difficulties.

About the incidence of otitis media and hearing dysfunction among preschoolers

Feagans' research summary says:

> It is the second most frequent reason parents take their children to the physician and the single most frequent diagnosis made by pediatricians (Shurin, Pelton, Donner, & Klein, 1979; Teele, Klein, & Rosner, 1984). In 1982 it was estimated that two billion dollars a year were spent in health care for this disease alone (Feigin, 1982). . . . Estimates have indicated that from 30 to 50% of children experience otitis media in the preschool years. But even these estimates have been based on acute episodes which rely on parents to bring their children to the physicians for treatment of symptoms. Studies which have examined children's ears on a regular basis, whether the child had signs of illness or not, have indicated that up to 75% of children under the age of five experience an episode of otitis media and that between 50% and 75% of these episodes are silent ones (Marchant, Shurin, Turczyk, Wasikowski, Tutihasi, & Kinney, 1984; Schwartz, Stool, Rodriguez, & Grundfast, 1981). These silent episodes of otitis media are ones in which the child has no fever or other presenting symptoms.
>
> Although the advent of penicillin-type antibiotics reduced the spread of the bacterial infection which could result in mastoiditis and other dangerous secondary infections, there is still no treatment for the fluid (effusion) that often remains behind the tympanic membrane for days or months after the acute infection has subsided. . . . From the parents' and physicians' points of view, the reduction in fever and pain with an antibiotic regimen belies the long-term developmental effect of the hearing loss. Thus, most parents are unaware of the hearing loss and most children do not show any aberrant behavior for which parents seek help. . . . The child with persistent otitis media is likely to have periods of prolonged mild hearing loss and then other periods when he/she can hear normally.

Stewart's research summary says:

> Recurrent middle ear disease is a major problem nationally in terms of the numbers of children affected as well as the drain it places on the nation's health resources. . . . Otitis media is the most frequent diagnosis made by physicians who care for children (Bluestone, 1981). . . . In 1981 there were approximately 21 million patient visits for otitis media to health professionals (Bluestone, 1983). Fully half of acute care visits to pediatricians in this country in some way involve the diagnosis, treatment and follow-up management of otitis media (Wientzen, 1983). About one visit in three for illness of any kind resulted in the diagnosis of a disease of the middle ear. Approximately three-fourths of all visits to follow-up any illness were made to follow-up diseases of the middle ear (Teele, 1983).
>
> The most prevalent complication and morbid outcome of otitis media with effusion is hearing loss . . . (Bluestone, 1981). To a varying degree, fluctuating or persistent loss of hearing is always associated with acute or chronic otitis media with effusion.

Several reviews of research have confounded findings about the incidence of <u>active middle ear</u> infection with findings about the incidence of <u>hearing dysfunction</u>. In our search we have sought to distinguish between the findings about the incidence of otitis media (Table 1) and the incidence of hearing dysfunction. Active middle ear infection may or may not be accompanied by hearing dysfunction, and hearing dysfunction may be the result of past infections, trauma, genetic defect, or other causes. It is the loss of hearing function that can be expected to have educational consequences, whatever its cause.

Our search of the literature regarding the incidence of hearing dysfunction finds reported incidences ranging between 3 and 16 percent. Silverman (1971) reports that "statistics prepared by the U.S. Office of Education indicate that out of the 1968-69 school population of 51 million, more than 2.5 million had hearing levels outside the normal range; approximately 255,000 of these children required special

Table 1

Summary of Findings: Incidence of Otitis Media

STUDY	N	DESCRIPTION	INCIDENCE OF OTITIS MEDIA
Kaplan (1973)	489	Eskimo children followed through 10 years of life	78% of children had first attack of otitis media during first 2 years of life; 41% of these had perforations or scars on tympanic membrane
Teele (1980)	1,565	Children followed first three years of life	71% had at least one otitis media episode; 33% had three or more episodes
Dever (1982)	69	Marshall Islands children	60.3% active otitis media; 2.8% perforations
Fiellau-Nikolajsen (1983)	404	3-year old children examined over a 6-month period	42% incidence; at each of 4 examinations, approximately 30% of the children had middle ear effusion
Ingvarsson, Lundgren, & Olofsson (1984)	--	Sweden	50% of study children experienced at least one episode; 18% experienced 4 or more episodes by age 5
Nieto (1984)	5,950	Random groups of children between ages 3 and 9 from 4 different climatic regions of Spain	16.2% in 3 year olds; 4.2% in 7-8 year olds.
Pukander, Sipila, & Karma (1984)	--	Finnish community	25% of children below 10 years; 51% of children aged 1-2 years; 75% of infants aged 6-11 months
Stewart (1984)	118	Palau Head Start children	65% failed hearing screening; 44% certified as handicapped.

Table 1

Summary of Findings: Incidence of Otitis Media (Continued)

STUDY	N	DESCRIPTION	INCIDENCE OF OTITIS MEDIA
Tos (1984)	--	Three different randomized child populations	13% active secretory otitis at age 1-year; 10-18 at ages 2-4 years. 80% of all ears and 90% of all children have had at least one episode of secretory otitis.
Casselbrant et al. (1985)	103	Group of 2-6 year old children from 2 Pittsburgh day-care centers	53% of children in first year developed otitis media; 61% of children in second year
Flear (1985)	115	3-5 year old Yapese children	17.4% active otitis media; 5.2% perforations.
Fosarelli (1985)	279	Inner city infants under 12 months of age	Average of one episode of otitis media; 19% experienced more than two episodes
Roberts, Sanyal, Burchinal, et al. (1985)	61	Black, socio-economically disadvantaged children enrolled in daycare	100% of sample Mean number of episodes 0-3 years of age 6.9 Mean number of days of otitis media with effusion 0-3 years of age 186.8
Wilson (1985)	90,000	Primary school children from Burma	5.6% had a hearing defect which interfered with normal hearing. Of these, 80% were caused by otitis media.
Dever (in press)	114	Health screening of Palau (Micronesia) Head Start Program	33% significant middle ear disease, 15% perforations of one or both tympanic membranes

educational services" (p. 287). Thompson, Gothard, Sturn, and Royster (1979) report that of 1,393 4-year-olds screened (audiometry) 16 percent failed, with 27 percent of those who passed initially failing when rescreened at a later time. Van Uden (1985) reports that about 4 percent of school-age children have a hearing impairment such that they need special help. Sturner, Green, and Funk (1983) found in examining two separate cohorts of preschoolers aged 52-70 months that 8 percent failed audiometric screening in 1978 and 12 percent failed in 1979. The State of Hawaii Department of Education reports that 3 percent of the 6,503 preschoolers screened were referred. These reports are based on arbitrary standards that vary from study to study. We can find no research that establishes the level of hearing required to function adequately in a typical classroom.

Though the research on the incidence of hearing dysfunction among preschoolers, and its relationship to otitis media, is marred by imprecise use of terminology, it seems clear that the failure rate on hearing screening found among Kamehameha Schools entering preschoolers is not unusual and is not unique to ethnic Hawaiian children.

About the relationship to family characteristics

Feagans reports:

> A variety of studies have shown an association between otitis media and socioeconomic status. In a study of 407 Canadian Indians there was a striking relationship between middle ear pathology and social ratings based on observations of housing conditions, house-keeping, income, and family functioning (Cambon, Galbraith, & Kong, 1965). . . . Living in crowded conditions, in apartments, or in cities has placed children at higher risk of otitis media than living in a rural area or in a single-family dwelling (Pukander, Spila, & Karma, 1984). Having more siblings also placed children at greater risk. All of these factors are more prevalent in low-income homes.

> Especially important . . . has been the consistent finding that children in day-care are at much greater risk for otitis media than children who stay at home. A large-scale epidemiological study in Denmark using 938 children in two birth cohorts were followed for three years (Fiellau-Nikolajsen, 1979). It was found that children in day-care were three times more likely to have an abnormal tympanogram than children who were at home.
>
> Other studies using a variety of other techniques have also confirmed this relationship between day-care and otitis media (Haskins & Kotch, in press; Vinther, Brahe-Pedersen, & Elbrond, 1984). Premature infants have been shown more likely than other infants to contract otitis media (Berman, Balkany, & Simmons, 1978).

Stewart reports:

> Particularly intriguing is the idea raised by several authors which suggested that some children may be more vulnerable to the morbid aspects of otitis media than others. Two groups which have been suggested are those of low socioeconomic status as well as those children in bilingual or trilingual language homes. Ruben (1984) speculated that there may be a strong relationship between negative impact of otitis media on achievement and socioeconomic status. He reported a previous study which demonstrated that the higher the socioeconomic class of children with sensory-neural or conductive hearing losses, the more closely the children approximated the normal hearing performance. This was true because of the greater advantages afforded to these children, including a greater opportunity for educational and social experiences, greater value placed on communication, and better health care. This suggests that the extent of the effect of auditory deprivation is proportional to the qualitative and quantitative amount of deprivation as well as to the background upon which it is placed. . . .
>
> Considerable controversy reigns regarding whether or not there is a relationship between poverty and otitis media. This ranges from the statement by Cambon (1965) that "the running ear is the heritage of the poor" to a statement by Tos (1983) that "SOM is not a poor man's disease". In the Boston study, children living in households with many members were more likely to have otitis media than were children living in households with fewer members (Teele, 1980). Van Cauwenberge (1984) failed to find a relationship between the socioeconomic status of the child's family and the incidence of otitis media.
>
> Therefore, the question remains open. Otitis media certainly does exist in all socioeconomic groups. Although it is not only a poor man's disease, there does seem to be

> significant evidence of some higher incidence where there are crowded living conditions, poor sanitation and inadequate medical care. Of special concern are the reports of greater severity and likelihood of more complications in poor children rather than more affluent children.

Delgado (1981), reporting the results of a national survey of children from non-native language homes, indicates that "there is a steady increase in the number of these (hearing-impaired) children nationwide. . . . Though educators express a deep concern for these children, relatively little was reported by way of accommodating their needs" (p. 121).

About the effect on learning and language development

Feagans summarizes her review as follows:

> Recent evidence has begun to accumulate that the intermittent hearing loss associated with otitis media may have long-term effects on the language and cognitive development of the child, especially because the hearing loss occurs during the language formative years. . . . Thus, it is most frequent during the time that children are acquiring many important cognitive skills, including the acquisition of language. . . . Menyuk (1980) has postulated that the mild fluctuating hearing loss can cause problems in language acquisition because the child is continually using a different input base from which to infer the rules of the language, including phonological, semantic, and syntactic rules. . . . It has only been in the last fifteen years that evidence has begun to accumulate about the relationship between otitis media and later language and learning problems. . . . Although more and more studies are being published about the possible long-term effects of this disease, most parents and physicians are unaware of the possible long-term consequences for the otitis-prone children.
>
> One of the first studies to indicate a relationship between otitis media and later problems was a report by Holm and Kunze (1969). They studied 16 children who had a history of chronic otitis media and compared them with a group of children who were matched on age, sex, and race. They found that the high otitis media group had significantly lower scores on vocabulary and language tests. Howie (1979) studied two groups of children who were matched on the same factors, and with the important added one of SES. The high otitis children were again found to have lower IQ scores and poorer reading and language scores. . . . Zinkus and his associates (Zinkus &

Gottlieb, 1980; Zinkus, Gottlieb, & Shapiro, 1978) carried out a series of studies using children in elementary school who were referred to a clinic for academic under-achievement. . . . The findings from these studies indicated that the otitis media group had significantly more verbal and academic deficits than the low otitis group. Other retrospective studies which have specifically studied children with learning disabilities have found that these children had a higher incidence of otitis media (Freeman & Parkins, 1979; Masters & Marsh, 1978). . . . In the Denedin sample (n = 951), children who were followed from birth and later identified as having behavioral problems by parents and teachers were examined. These 90 identified children had significantly more otitis media and this relationship was even stronger when the hyperactive children were only used (n = 30) (McGee, Silva, & Stewart, 1982). In another study from this same sample (Silva, Kirkland, Simpson, Stewart, & Williams, 1982), children with bilateral otitis media matched to children with no otitis media on background characteristics, were observed to have shorter attention spans, and were reported to be more restless, fidgety, and destructive. In addition, there were also lower scores found in speech, language, and intelligence for these children with bilateral otitis media.

Stewart reports:

A substantial body of evidence exists that relates impairment in children's language to the presence of chronic and continuous middle ear disease and conductive hearing loss (Rapin, 1979). This relationship is assumed to be mostly causal in nature. However, there has been considerable lack of agreement whether a similar causal relationship exists between intermittent middle ear disease and fluctuating hearing loss (Paradise, 1981; Hubbard, 1985).

A report from London (Bax, 1981) reported a five year study carried out on 870 children. He described a highly significant relationship between language delay at two years and reported incidence of otitis media with effusion in the previous six months. At age three years, the percentage of children with otitis media with effusion among those showing language delay was twice as high as among the group of children that showed normal language development. Hubbard (1984) concluded that his study supported earlier hypotheses that long-standing otitis media during early life may result in impaired speech during later childhood, but failed to find a relationship with subsequent language development. Needleman (1977) concluded that articulation errors were greater in children with histories of repeated episodes of otitis media than in children who did not present such histories. Shriberg (1983) recently reported similar results.

> An extensive study by The Greater Boston Otitis Media Study Group looked at the effect of otitis media with effusion during the first three years of life and development of speech and language. . . . Their findings convincingly showed that children who suffered from recurrent acute otitis media with effusion and thus spend prolonged periods with middle ear effusion scored less well on tests of speech and language administered at age three years than did children who spent little or no time with middle ear effusion. However, in contrast to other studies, they found that children of higher socio-economic status were at greatest risk for poor performance. Time spent with middle ear effusion in the first year of life were most strongly associated with lower scores on tests of speech and language.
>
> Many of the preceding studies have been criticized for various research design flaws. Menyuk (1979) outlines suggestions for designing definitive studies to address the issue of relationship between early and intermittent hearing loss from otitis media and subsequent language development which would address the design limitations of earlier studies. However, in the meantime, during the Workshop on Effects of Otitis Media on the Child, the following statement was made (page 643):
>
> > "Some 30 studies involving 3,500 children has shown a consistent association of early fluctuant hearing losses with later decreased learning skills. Although design weaknesses abound, ... no amount of cavilling over experimental design can obviate the fact that serious attention must be given to these findings."

Our review of the literature regarding the relationship between hearing dysfunction and educational achievement is consistent with the findings of Feagans' and Stewart's reviews. Keith (1985) and Bess (1985) find that educationally, the presence of fluid in the middle ear "and its associated hearing loss result in significant sensory deprivation, with far more educational difficulty than was previously supposed" (Bess, 1985, p. 47). Glass (1981) reports significant associations between three auditory subtests of the ITPA and a history of otitis media and auditory learning disability. Davis, Elfenbein, Schum, and Bentler (1986) report that "even the mildest hearing losses are likely to result

in delays in vocabulary development" (p. 57). Eimas and Kavanaugh (1986) report a significant relationship between conductive hearing loss resulting from recurrent otitis media during the first 3-5 years of life and subsequent problems in acquisition of language and academic skills. "Even a 'mild' hearing loss of 15-25 dB in early childhood if persistent . . . and if neglected . . . may not only disturb the acquisition of language but also adversely affect the social and emotional development of a child" (p. 290).

The literature on the relationship of hearing dysfunction to educational achievement contains some seriously flawed research. In general, designs are weak, samples are small and non-representative, and measurement procedures have been less then optimally reliable. Misleading interpretations have sometimes been drawn from the results of psychological and educational tests. For example, verbal intelligence tests that stress reasoning ability have been confounded with tests of language achievement (understanding and usage of speech) as measures of "language development" (Howie, 1979; Roberts et al., 1986; Davis, Elfenbein, Schum, & Bentler, 1986). Not surprisingly, hearing dysfunction appears to be less critical when "language development" is operationally defined by intelligence tests than by tests designed to assess educational achievement of specific language skills.

The literature on hearing dysfunction and its relation to language competence is complex and confused from a number of viewpoints. Sometimes the subject of research is identified as otitis media (middle ear infection), sometimes hearing loss, sometimes hearing deficiency, sometimes auditory processes, sometimes language development, sometimes

conductive hearing loss. There are no consistent operational definitions of such terms. Some research addresses a medical condition (such as infection) while other studies deal with the perceptual function (hearing).

The studies reviewed here use a variety of methods to determine the incidence of hearing dysfunction. These typically are tympanometry, audiometry, and otoscopy, with some use of parental recollections of previous hearing problems and medical histories. The great majority of these studies do not use a multiple-method technique. That is, a few studies use all three of the techniques, but most rely on only one. The reported incidence of hearing dysfunction varies depending upon which techniques are used. Further, each method measures or assesses more than one thing. Results of otoscopic examination are not limited to findings of active or past otitis media; other findings may include evidence of trauma, obstruction, or congenital problems. A tympanogram may be abnormal, but the cause, and the effect on auditory acuity, may be unknown. The abnormality may be due to otitis media, but also to poor cooperation on the part of the subject or poor testing conditions. Reports of results of audiometric examinations are subject to similar limitations of interpretations.

Olmsted, Alvarez, Moroney, and Eversden (1969) report the results of a study in which serial audiometric measurements were obtained in 82 children seen as outpatients with a diagnosis of acute otitis media. These children had had no preceding history of chronic otitis media or hearing loss. Thirty-three percent of the children had no demonstrable impairment immediately following the acute infection. Fifty-five percent

of the children had losses of hearing which cleared within 1-6 months and 12 percent had losses which persisted for the 6-month period of observation. Eagles, Wishik, and Doerfler (McDermott, 1982) report that 61 percent of the children with otoscopically abnormal ears passed the standard pure tone sweep check. Fifty percent of the children who developed ear pathology during the study continued to pass subsequent pure-tone sweep tests.

Catlin (1984) notes that "a variety of methods to assess hearing have evolved . . . (but) their ability to represent overall hearing function is questionable" (p. 241). Moore and Best (1979-80) urges a team approach (otologist, audiologist, educator) to recognize the possibilities of serious educational and social problems associated with chronic otitis media.

Another source of complexity in the literature concerns the populations chosen for study. In many studies screening of Head Start or day-care children is undertaken to determine the incidence of otitis media. In others, children are referred because of some other existing condition, such as poor language development. Medical histories, parental recollection, and otoscopic examination are then used to identify the present or past incidence of otitis media. Other studies match and assign children to groups on the basis of present or past otitis media and current demographic background variables. The small numbers of children selected for study and the manner in which the children were selected lead to varying findings, making interpretation of the literature difficult.

Ventry (1980), in examining the effects of conductive hearing loss, comments that

> A careful evaluation of published research on the relation between conductive hearing impairment and language and learning difficulties suggests that the relationship had been poorly documented, that methodological flaws in the published research have contaminated the data and confounded the reported results, and that there is a continuing need, as so many investigators have emphasized, for ongoing research in this area. (p. 150)
>
> The accumulation of valid empirical evidence from research with different subjects, different experimenters, different settings, and different tasks will allow us to answer the question: What are the effects of conductive hearing loss on children? At present, we cannot answer the question. The research must continue, albeit at a higher and more rigorous level than in the past. (p. 155)

A further complexity is found in the linkages among otitis media, hearing dysfunction, and language competence. Studies have shown that even mild and intermittent hearing losses can cause language learning problems and that these hearing losses are usually due to otitis media. Northern and Downs (1974) find that of cases of hearing losses in children who reach school age, 90% are caused by otitis media. However, not all children who experience otitis media suffer hearing dysfunction. Further, hearing loss from whatever cause is only imperfectly correlated with impaired language skills. Children may also recover language skills lost from such causes later. Nevertheless, on a statistical basis, there is a relationship between otitis media and hearing dysfunction and also between hearing dysfunction and impaired language competence. Though there are links between these three, it is difficult to determine reliably the exact size of the correlational links. Despite these difficulties it is reasonable to conclude that the links exist.

The objective of this research was to determine the relationships among the high incidence of hearing dysfunction found among Hawaiian preschoolers, their performance on educational tests administered at the beginning and at the end of their preschool year, and family characteristics. The implications of the findings for program developers, teachers, parents, and health professionals are considered.

II. METHODS

The five preschools operating under the auspices of Kamehameha Schools/Bishop Estate (KS/BE) in 1985-86 enrolled approximately 100 children at about the age of four years and six months. Eighty-five percent of these children were of pure or part-Hawaiian ancestry. Upon entrance, the preschoolers were given the Peabody Picture Vocabulary Test (PPVT-R) and five tests from the CIRCUS battery: Language Understanding, Language Usage, General Information, Quantitative Concepts, and Psychomotor Skills. These tests were re-administered at the end of the school year.

A team of audiologists from a children's hospital was contracted to provide the hearing screening. This screening included pure-tone audiometry, otoscopy, and tympanometry. In our screening the children were classified as "Fail" if they failed the audiometry or the tympanometry, or the otoscopy produced a "Questionable" finding in any combination of these three. Only 14% of the children passed the hearing screening.

One parent (or guardian) of each preschooler was interviewed by a KS/BE staff member at the end of the school year. (Interviewers failed to contact 13.) A 25-question interview was used to obtain a detailed description of the child's family, including the marital, occupational, and educational status of the parents; parental and household income; and parental expectations and aspirations for the child's educational future.

III. RESULTS

The number and percent of children assigned to each category of hearing-screening result by each of the screening methods are shown in Figure 1. The correlations among the screening methods are presented in Table 2. The cross-tabulation of the hearing-screening results by screening method is shown in Table 3; the congruence among the findings of these screening methods is shown in Figure 2. In this figure (a Venn diagram) the size of the circles is approximately proportional to the number of children who "did not pass" each of the screening methods. The overlap of the circles indicates congruence of findings. For example, 25 children did not pass any of the three screening methods, 28 had questionable otoscopy results only, 10 had questionable otoscopy results and failed audiometry but not the tympanometry, and so forth.

Table 2

Correlations Among Screening Methods

	Audiometry	Tympanometry	Otoscopy
Audiometry	--		
Tympanometry	0.64	--	
Otoscopy	0.07	-0.01	--
Referral status	0.82	0.65	0.38

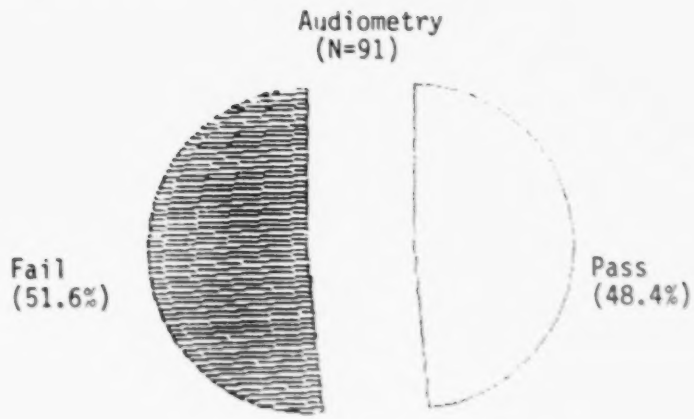
The three screening methods yield results that are in substantial agreement, though otoscopy identifies a larger proportion of children as

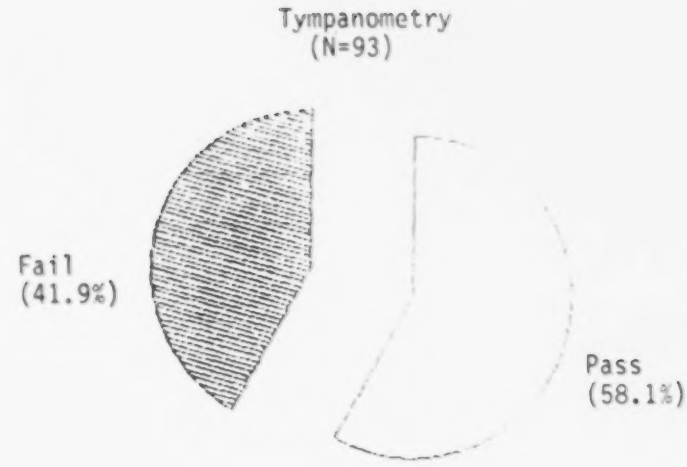
failing the screening. The summary clinical judgment of the audiologists (Referral Status in Figure 1) is based on a professional interpretation and integration of the three screening techniques.

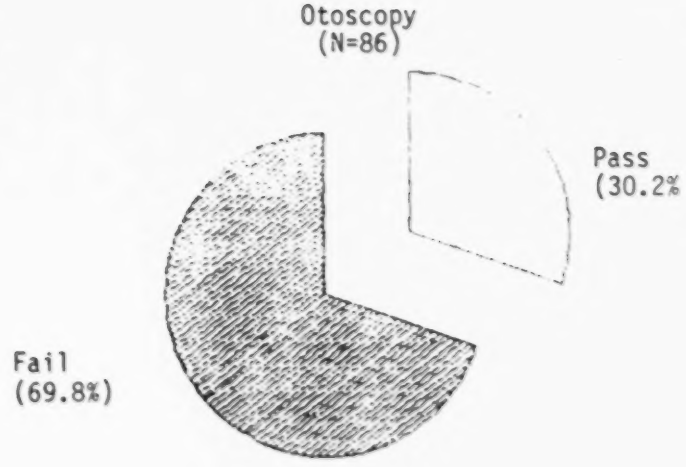
Differences in family characteristics of children who passed and failed the hearing-screening were tested for significance (discrete variables by chi-square and continuous variables by single-classification analysis of variance). These results are presented for each screening method in Table 4. Though Hawaiian children were more likely to fail the hearing screening than non-Hawaiian children, generally no relationships between family characteristics and hearing dysfunction were found.

The differences in performance on the educational tests of children passing and failing the hearing screening are shown in Figures 3 through 6. Each figure displays the results for a different screening technique. It is evident that there is a significant relationship between test-performance and hearing-screening results when language skills are tested.

These findings of statistical significance tend to support the reliability of the hearing-screening methodology. False positives would not be associated with lower test-scores. Further, the fact that these significant differences are found with tests administered in the Spring (some seven or eight months after the hearing screening) focusses attention on the educational implications of these findings.







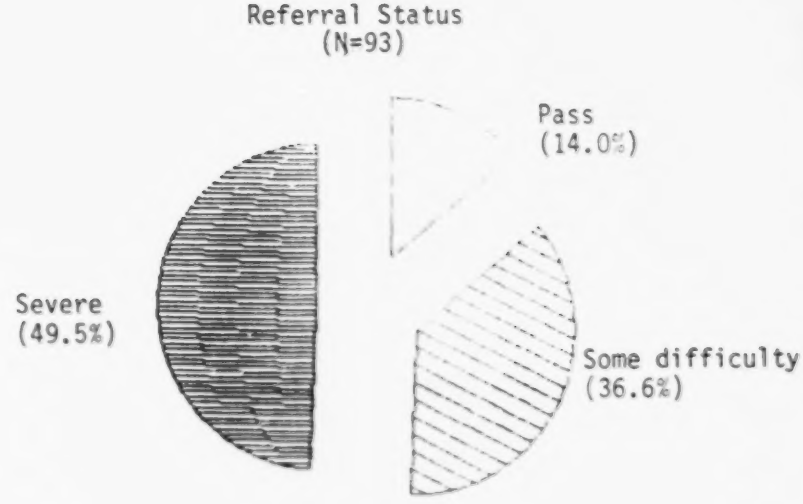


Figure 1. Hearing screening results by method.

Table 3

Cross-tabulation of Results by Screening Method

	AUDIOMETRY				
	Pass		Fail		
	OTOSCOPY		OTOSCOPY		TOTAL
	Pass	Fail	Pass	Fail	
TYMPANOMETRY					
Pass	12	28	3	10	53
Fail	2	2	9	25	38
Total	14	30	12	35	91

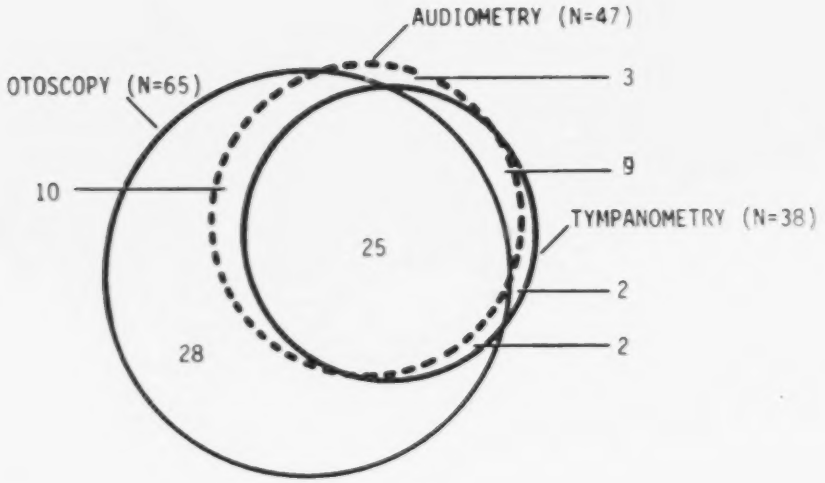


Figure 2. Congruence among "fail" findings of screening methods.

Table 4

Screening Method Results and Family Characteristics*

FAMILY CHARACTERISTICS	AUDIO-METRY	TYMPANO-METRY	OTOSCOPY	REFERRAL STATUS
Age			X	
Gender				
Health				
Race (Hwn. vs. non-Hwn.)	X			X
Custody				
Previous preschool experience				
Parents' presence in household				
Parents' marital status				
Parents' DSSH status				
Parents' income				
Household income				
Percapita income				
Father's education				
Mother's education				
Birthweight				
Household size				
Sibling set size				
Birthorder				
Number of children aged 0-5 in the household				
SES				
Parents' aspirations for student's grades				
Parents' expectations for student's grades			X	
Parents' aspirations for student's schooling				
Parents' expectations for student's schooling				
Change in parents' employment status				
Child's change of household (Moved Y/N)				
Persons entered into household (Y/N)				
Persons left household (Y/N)				

* X indicates a statistically significant relationship (chi square or r) between screening method results and the family characteristic (.05 level)

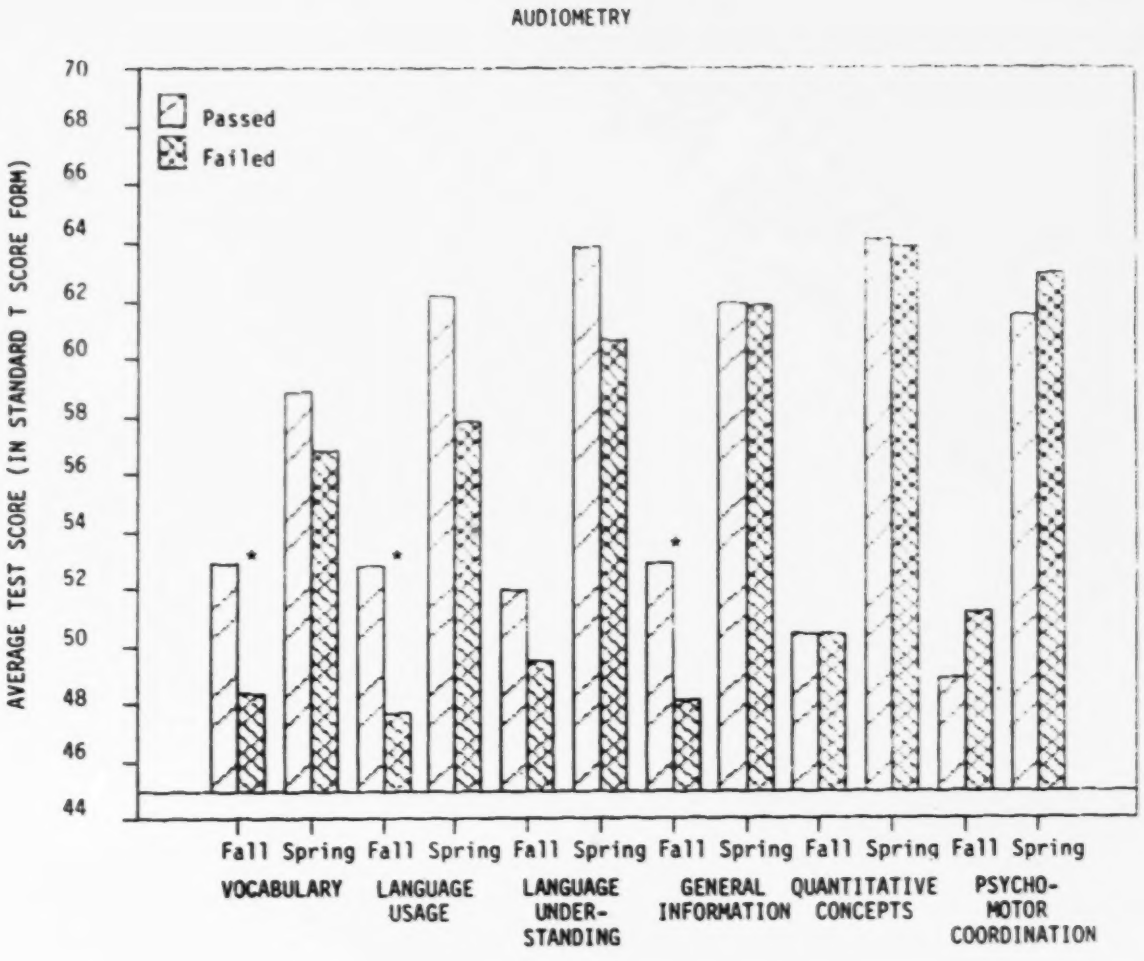


Figure 3. Comparative test performance of preschoolers who "pass" and "fail" the audiometry screening.

*Difference between mean test score of hearing "pass" and "fail" groups significant at the .05 level

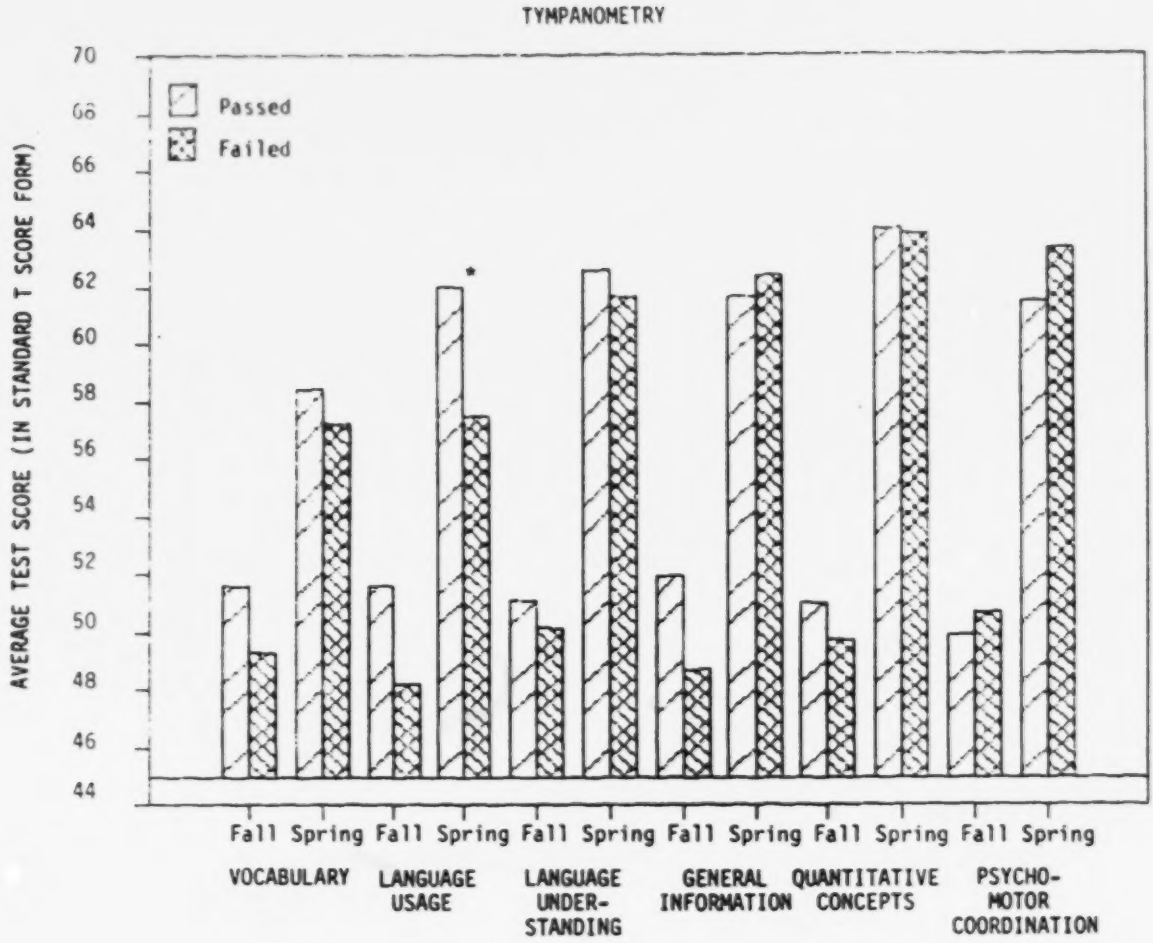


Figure 4. Comparative test performance of preschoolers who "pass" and "fail" the tympanometry screening.

*Difference between mean test score of hearing "pass" and "fail" groups significant at the .05 level

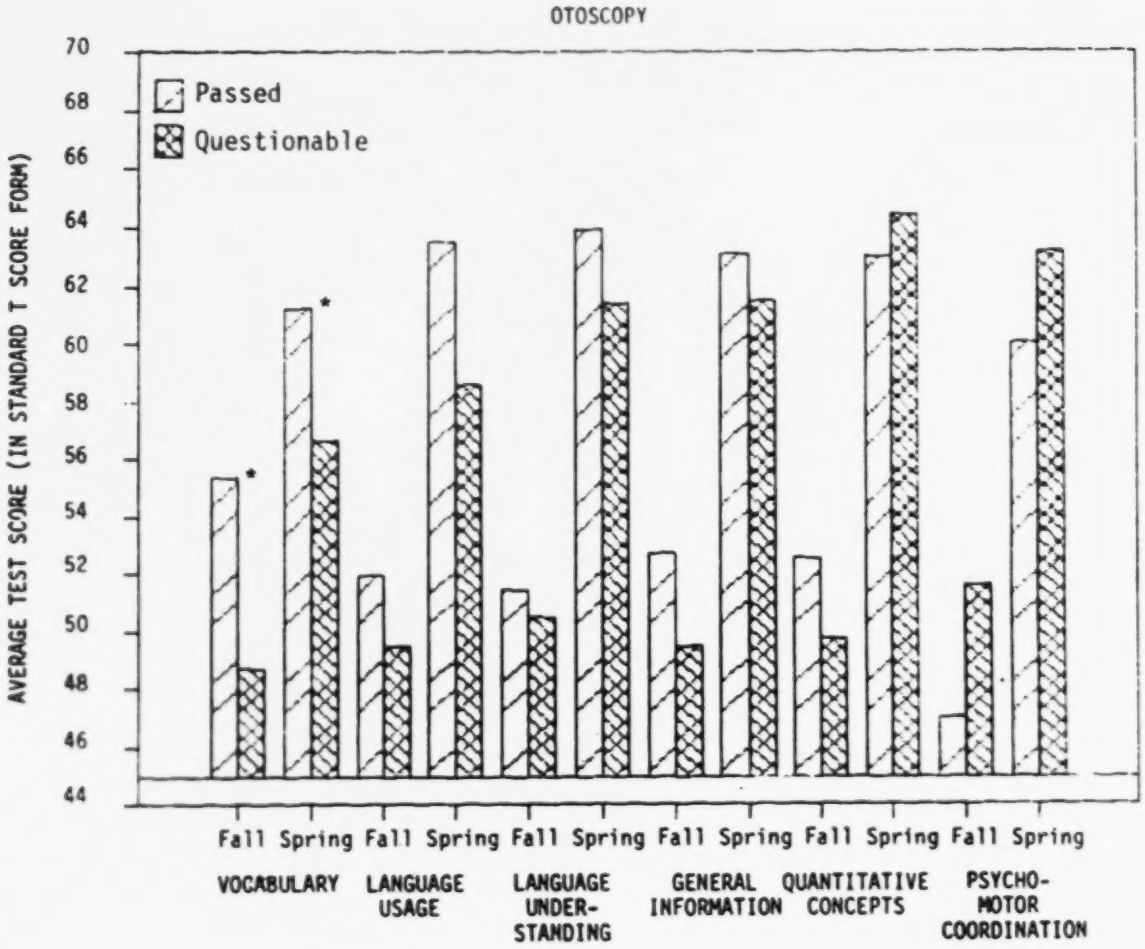


Figure 5. Comparative test performance of preschoolers with "pass" and "questionable" results on the otoscopy screening.

*Difference between mean test score of hearing "pass" and "fail" groups significant at the .05 level

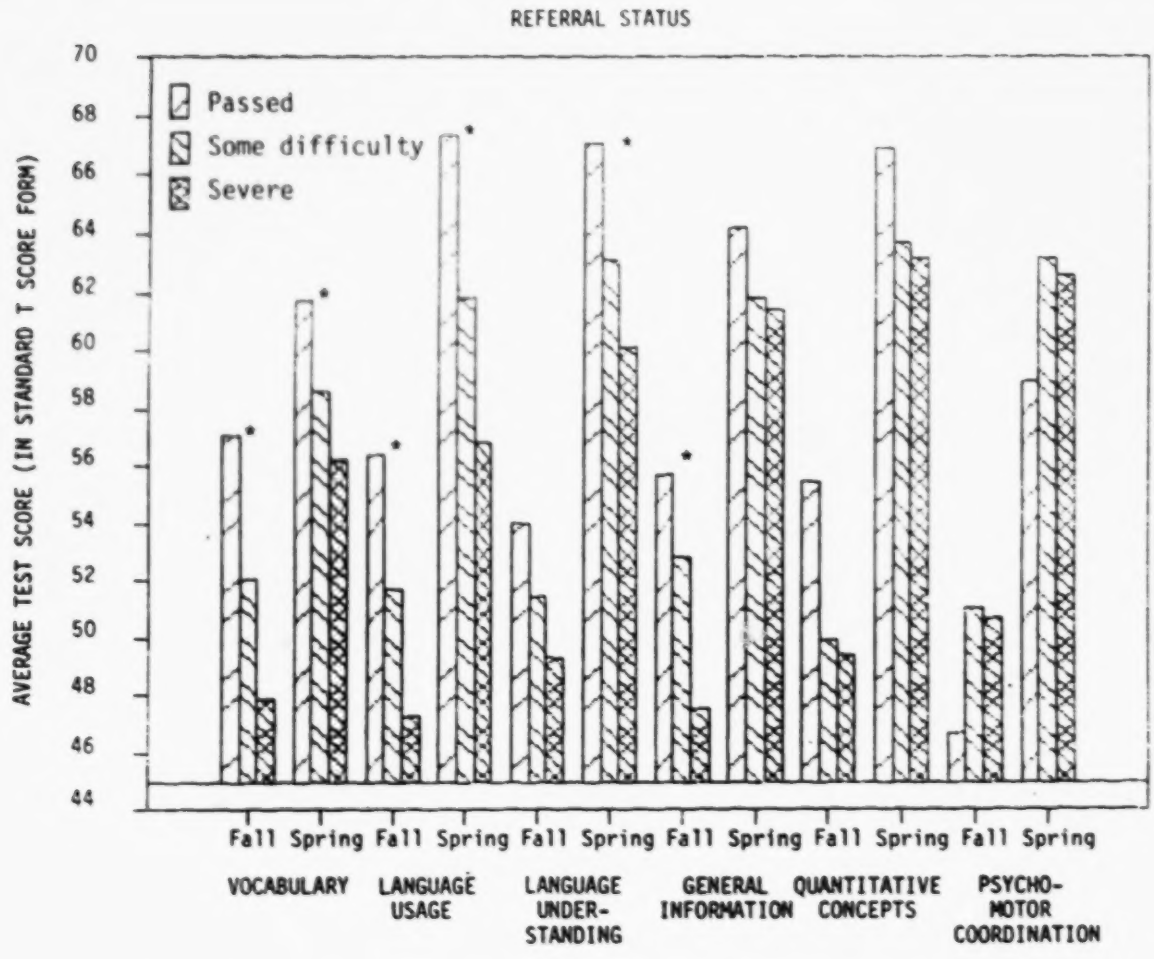


Figure 6. Comparative test performance of preschoolers by hearing screening referral status.

*Difference between mean test score of referral status "pass" and "severe" groups significant at the .05 level

IV. DISCUSSION

The literature review and the analyses reported here were conducted in search of answers to eight questions:

1. **How unusual are the findings of the hearing-screening of preschool children at Kamehameha Schools?**

The research literature, especially the most recent literature, indicates that these findings <u>are not</u> unusual. Contemporary studies report that <u>most</u> children experience episodes of "silent" otitis media, that these episodes recur during the preschool years, and that the effects on hearing endure for weeks or months following each episode. Further, these research reports suggest that the incidence of episodes of otitis media is higher for children in particular ethnic minorities, in low-income families, and for children who are exposed to greater opportunities for exchange of infection (group-care settings, crowded housing, larger numbers of siblings). Many of the factors associated with a higher incidence of this type of hearing dysfunction are characteristic of the population of children served by KS/BE preschools.

2. **Is it likely that these findings are in error?**

Our data offer two means of examining the likelihood of error in the hearing-screening: (a) congruence, or lack of congruence, among the findings of the three screening techniques and (b) the relationship of the screening results to test scores that may be expected to be influenced by hearing function.

In these data the congruence of the findings among the three screening techniques is striking. Even though the techniques address

very different aspects of audition, they identify the same children to a substantial degree. When the findings produced by the individual techniques are integrated and interpreted by a professional audiologist, the convergence of results yields a more statistically valid categorization of children by hearing status (see Table 2).

Further evidence of the reliability of the hearing-screening findings is derived from the relationship of these findings to the test performance of the preschoolers. On those tests that one would expect to be most vulnerable to hearing dysfunction (tests of language skills) children who fail the screening score significantly lower than those who pass. This relationship can be observed not only when the tests are administered concurrently with the hearing screening, but also when the same tests are administered again, some eight months later.

3. Is this incidence in hearing dysfunction unique to Hawaiian children?

The current research literature indicates that the incidence of hearing-dysfunction found in these data is <u>not</u> unique to Hawaiian children. However, there appears to be an emerging body of research indicating that certain ethnic groups (Native Americans, Pacific Islanders, Eskimos) may be at greater risk than the general population (Kaplan, Fleshman, Bender, Baum, & Clark, 1973; Spivey & Hirschhorn, 1977; Fischler, Todd, & Feldman, 1985; Todd, 1983; Toubbeh, 1985). Truly systematic research on the magnitude and the nature of the relationship between ethnicity and hearing-dysfunction in young children appears to be in a beginning stage.

4. **Are such findings a function of the screening method used?**

These data indicate that the various screening methods generally produce the same findings. To the extent that any one of the techniques yields differing results, that method is otoscopy. However, otoscopy is not a direct measure of auditory functioning. Its results take the form of a subjective judgement on the part of the examiner. Each of the screening methods yields a distinct type of data, and when these data are integrated by a trained specialist, the resulting assessment appears to filter out anomalous results that might be obtained from any one technique used alone.

5. **Is hearing-dysfunction among Hawaiian children related to family characteristics?**

There are virtually no significant differences in hearing screening results related to family characteristics, other than ethnic-Hawaiian status, in these data. On some variables (such as SES) the range is so small that any significant relationship is precluded. However, with many variables that might be expected to be associated with the incidence of otitis media (such as sibling-set size, birthweight, number of children aged 0-to-5 in the household) there is no significant relationship in evidence.

6. **What is the relation of hearing-dysfunction to performance on educational tests?**

Though there are variations by screening method and test, a clear pattern of significant findings is evident from the analyses of data reported here. Statistically significant differences are found in the performance on tests of language skills between preschoolers passing and

failing the hearing screening. Such differences are not found in performance on tests of psychomotor skills and tests of quantitative concepts. Poor performance on language tests by children identified as having hearing-dysfunction is apparent when these tests are administered eight months after the hearing screening as well as on tests administered concurrently with the hearing screening. The subtleties of language usage appear to be particularly vulnerable to the effect of hearing-dysfunction. It is just that aspect of education in which Hawaiian children experience the greatest academic failure at all grade levels.

Though there are other social and linguistic factors that likely contribute to the language-competence problem of Hawaiian students, the importance of hearing-dysfunction in the critical language-acquisition years may have been underestimated. The educational effects of hearing-dysfunction may be considerably more tractable than other antecedents of educational failure.

7. **What are the implications of these findings for educational program planning for Hawaiian preschoolers?**

It would be comforting to believe that a medical solution to this educational problem was forthcoming. Unfortunately, such a solution in the near future seems very unlikely. There are approximately 93,000 children under the age of five in Hawaii. If 75% of these (10% less than we found) experience hearing-dysfunction, about 70,000 (20,000 of them Hawaiian/part-Hawaiian) of these children will require drug and/or surgical treatment.

Recent medical literature indicates that purely medical solutions to the educational problems (primarily diminished language competence)

caused by the prevalence of otitis media are not likely, may not be necessary, and may entail undesirable risks. An article by Paradise (1981), makes the point that

> The complications, sequelae, and risks--known and potential--of tympanostomy tube insertion, to say nothing of the resulting inconvenience and the cost, are far from inconsequential. Psychological trauma, anesthetic risks, secondary infection, and eardrum scarring constitute the known, main items of concern; to these must be added the possibility that the placement of tympanostomy tubes might predispose to the eventual development of more serious ear disease, or permanent impairment of hearing, or both (p. 872).

Paradise and Rogers (1986) remind pediatricians that

> The stakes are substantial in these thorny and interrelated questions regarding the long-term effects, and optimal management, of early otitis media. Involved are the otologic, audiologic, and developmental outcomes of millions of children and the performance or nonperformance of myringotomies and tube placements. Until satisfactory answers are available, clinicians must recognize that the questions persist and must avoid treatment decisions based on evidence that is inconclusive (p. 91).

Even if it were clear that such treatment were safe and successful (and that is <u>not</u> clear), it is unlikely that such medical care will reach this population of children in the foreseeable future. In any case, those children who are now manifesting impaired language competence cannot be ignored. Whatever happens in the practice of medicine, educators have their own professional responsibility to consider.

Our search of the literature has brought us to the same conclusion that Feagans (in press) reached ". . . there is almost nothing in the literature to guide the development of a program for children at risk for otitis media."

Other research workers and educators have speculated about a variety of techniques that may be useful in counteracting the educational

consequences of hearing-dysfunction in the preschool. Sustained, one-to-one, adult-to-child interaction, joint book reading, question-and-answer sessions, reduction of ambient noise in the classroom, and a variety of other methods have been proposed.

We can find no systematic research on the effectiveness of such methods. Until this research is undertaken, program developers and teachers will have only guesswork to guide them.

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